Proceedings of ANAS (Biological and Medical Sciences), vol. 73, No 2, p. 107-112 (2018)

Physiological Parameters of Maize *(Zea mays* L.*)* Varieties of Azerbaijan Breeding

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On the basis of the results obtained on Maize Breeding Program realized at Zagatala RES (Regional Experimental Station) of RICH, to compare the physiological parameters of C_4 plants *(Zea mays* L.) leaf assimilating surface area, leaf area index, dry matter accumulation, chlorophyll content in leaves, yield structural elements and productivity were analyzed and the relationship between the studied parameters were established.

Keywords: *Variety, maize, photosynthesis, chlorophyll content, leaf assimilating surface area, leaf index, yield structural elements, productivity*

INTRODUCTION

The most important biological features of maize are a broad genetic variability and high ecological plasticity, which ensure its adaptation in a wide range of environment (Chirkov, 1969, Kravchenko, 2010a, 2010b, Kravchenko, 2012). Due to the high biological adaptability, maize is able to grow and develop normally in various agro-climatic zones (Troneva, 2010). Therefore, the biological requirements of maize can fluctuate with large amplitude, due to the variation of the complex of interrelated biochemical, physiological, morphological and other characteristics (Francis, 1990). In addition, maize has a high productivity, which is due to the physiology of photosynthesis, a large leaf area, and high density of conducting system in them.

Maize refers to a small group of crops (mainly of tropical origin) that accumulate carbon dioxide in the process of photosynthesis according to the energy-efficient C_4 scheme (Shpaar, 1999). It gives a number of significant advantages in the formation of the yield. Maize has an increased coefficient of efficiency of photosynthetic active radiation (0.4-1.1% compared to 0.2-0.5% in wheat) and a biomass increase of 50-54 g /m^2 per day, while in plants of the C_3 group it is only 34 -39 g/m^2 (Gulyaev, 1989). The high energy absorption coefficient of solar radiation also ensured by the fact that leaves of maize plants contain a much higher amount of chlorophyll than other crops, which is the main pigment of green plants (Kayumov, 1989). The leaves of higher plants contain chlorophyll a and chlorophyll b, as well as carotenoids (carotin, xanthophyll, etc.).

The area of leaves in the sowing is expressed by the index of the leaf surface (ILS) - the ratio of the total surface of the leaves to the area of the soil covered with plants. Using this indicator, it is possible to evaluate the efficiency of the crop with respect to the accumulation of dry matter-the final result of photosynthetic activity.

The best is maintaining ILS, close to optimal. In this way, it is possible to maintain the optimum rate of accumulation of dry matter (Gelston, Devisc, Setter, 1983).

The purpose of the study. The purpose of this research was to study the effect of physiological parameters on the productivity of maize plants.

MATERIALS AND METHODS

Field experiments were conducted in the Parzivan experimental field of the Zagatala RES of the ARICH in 2014-2016. Phenological observations were carried out according to generally accepted methods. The area of the assimilation surface of leaves was measured using an automatic area meter (AAC-400, Hayashi Denkon Co., LTD, Japan).

The concentration of photosynthetic pigments (chlorophyll a, b and carotenoids) was determined in 96% ethanol. In the leaf extract, chlorophyll a, b and carotenoids were determined by spectrophotometer (Genesys 20, Thermo Scientific, USA) at wavelengths of 664, 648, 470 nm in 96% ethanol (Lichtenthaler, 1987). The yield was calculated by the grain output from cob. The subjects of the study were 10 varieties and variety samples of *Zea mays* L.

related to the species *Indendata Flavoruba, Indurata Vulqata* and *Indendata Leykodon*.

RESULTS AND DISCUSSION

During the vegetation period, phenological observations were carried out to ensure the establishments of stages of plant development, the duration of inter stage and vegetative periods, which, with respect to maize, are important feature that largely determines the level of productivity (Kravchenko, 2010a, 2010b).

For high yield, the leaves of maize varieties, which are considered to be the main photosynthetic apparatus, the assimilation surface area, their dynamics of growth and activity, are key indicators and their study is of great practical importance. The dynamics of the formation of the assimilating surface area of leaves is shown in Table 1. As can be seen in the table 1, at the beginning of ontogenesis in all studied varieties, the assimilating surface area of the leaves increased, after the tasseling the growth of the leaves somewhat weakened, and reached its maximum at the end of the flowering stage. This indicator in varieties Zagatala Yerli Yakhshylashdyrylmysh (Zagatala Local Improved), Gurur, Emil and Umud was respectively, 1.797, 1.403, 1.389 and 1.379 m^2, while in the other studied varieties it changed in the range of 1.082-1.373 m^2. Assimilating surface area of the variety Zagatala Yerli Yakhshylashdyrylmysh was more: 21.9-39.2% compared to other varieties. During the growing season, the assimilating surface area of the leaves of the lower part gradually decreased, and at the upper parts increased and the leaves located at the top had higher physiological activity. The difference in the photosynthetic activity of the leaves, as a result of the shading of the lower middle and upper parts, is explained by weak illumination.

The leaf area index of the varieties was also calculated and determined that at silking stage in varieties Zagatala Yerli Yakhshylashdyrylmysh (10.24 m^2/m^2), Gurur (7.999 m^2/m^2), Emil (7.918 m^2/m^2) and Umud (7.861 m^2/m^2) this indicator was higher in comparison to other varieties, while toward to the end of the vegetation it was decreased.

In varieties with a larger area of the assimilating surface and functional activity, the grain formation proceeds more intensively, this is reflected in the final yield. As a result of yellowing and biological aging of leaves, by the end of ontogenesis, the assimilating surface area decreased even more. The quantity and quality of the final maize yield during the growing season are closely related to the accumulation of dry biomass of the leaves. Therefore, a regular study of the accumulation of dry biomass of leaves and other parts of plant is of great practical importance. The accumulation of dry biomass during vegetation depends on not only developmental stages; it depends also on the genetic characteristics of the plant.

As can be seen in Fig. 1 the accumulation of dry biomass in one plant increases until the period of milk ripening, reaches a maximum and decreases to a period of complete maturity.

This parameter during the milk ripening in varieties Gurur, Zagatala 68 and Emil was 95.9, 91.3 and 90.8 g respectively, while in the other studied varieties - Fakhri and Umud varieties, 85.0 and 76.4 g, respectively. Accumulation of dry leaf biomass in the Variety Gurur was 4.54-19.4 g more in comparison with other varieties. And at the end of vegetation period this indicator changed in the range of 41.8-50.3 g.

Table 1. Assimilating surface area of leaves of one plant, m^2.

Name of variety	Development stages and leaf indices									
	15 leaves	leaf index	tasseling	leaf index	silking	leaf index	milk ripening	leaf index	wax ripening	leaf index
Zagatala 68	0.810±0.17	4.617	0.923±0.51	5.261	1.098±0.37	6.394	1.075±0.48	6.120	0.599±0.41	3.415
Zagatala 380	1.005±0.24	5.732	1.243±0.75	7.085	1.373±0.44	7.826	1.015±0.89	5.784	0.583±0.85	3.323
Zagatala 420	0.903±0.10	5.148	1.103±0.27	6.289	1.208±0.30	6.883	0.958±0.55	5.506	0.559±0.27	3.184
Zagatala 514	1.077±0.30	6.136	1.302±0.58	7.426	1.369±0.82	7.804	1.218±0.30	6.942	0.784±0.37	4.469
Zagatala Yerli Yakhsh.	1.305±0.27	7.439	1.565±0.27	8.921	1.797±0.68	10.24	1.309±0.37	7.458	0.889±0.92	5.068
Mirvari	0.847±0.55	4.825	1.022±0.79	5.826	1.189±0.48	6.775	0.870±0.92	4.960	0.463±0.68	2.638
Gurur	1.101±0.41	6.276	1.296±0.30	7.388	1.403±0.55	7.999	1.313±0.68	7.484	0.705±0.41	4.019
Umud	0.983±0.65	5.604	1.183±0.44	6.744	1.379±0.17	7.861	1.210±0.20	6.897	0.691±0.72	3.939
Fakhri	0.882±0.30	5.028	0.999±0.68	5.695	1.255±0.41	7.154	0.941±0.55	5.364	0.594±0.85	3.386
Emil	0.923±0.72	5.262	1.122±0.58	6.397	1.389±0.58	7.918	1.028±0.82	5.860	0.682±0.61	3.888
Populyasiya 2001 B	0.742±0.55	4.228	0.909±0.44	5.181	1.099±0.68	6.264	0.913±0.37	5.203	0.426±0.30	2.428
Populyasiya 2008 H	0.752±0.34	4.286	0.939±0.48	5.351	1.082±0.27	6.167	0.845±0.61	4.816	0.450±0.27	0.257

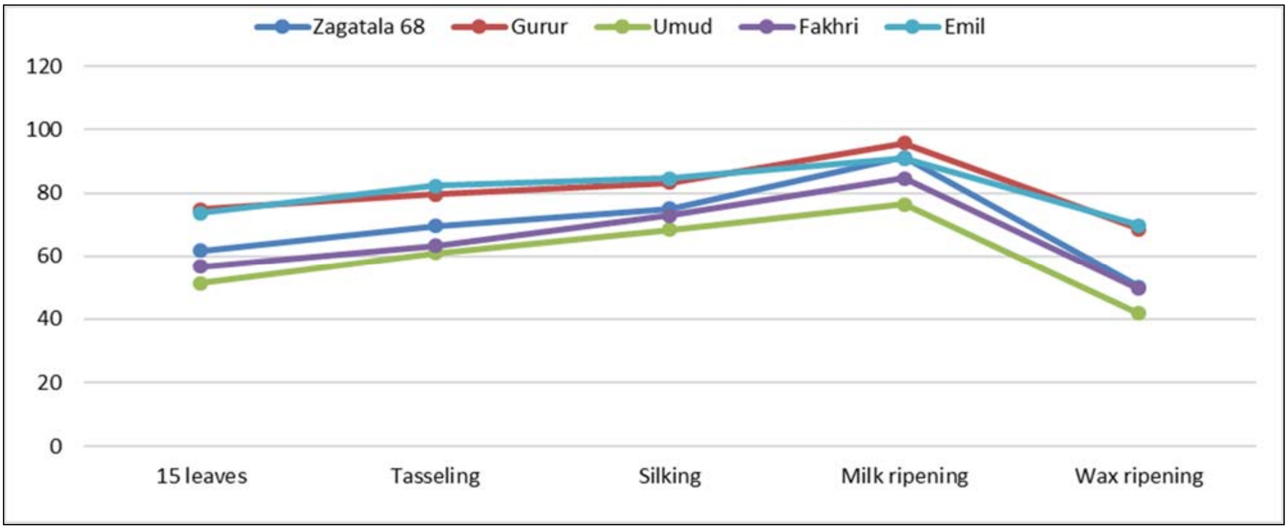


Fig. 1. Dynamics of leaf dry matter accumulation in one plant, g.

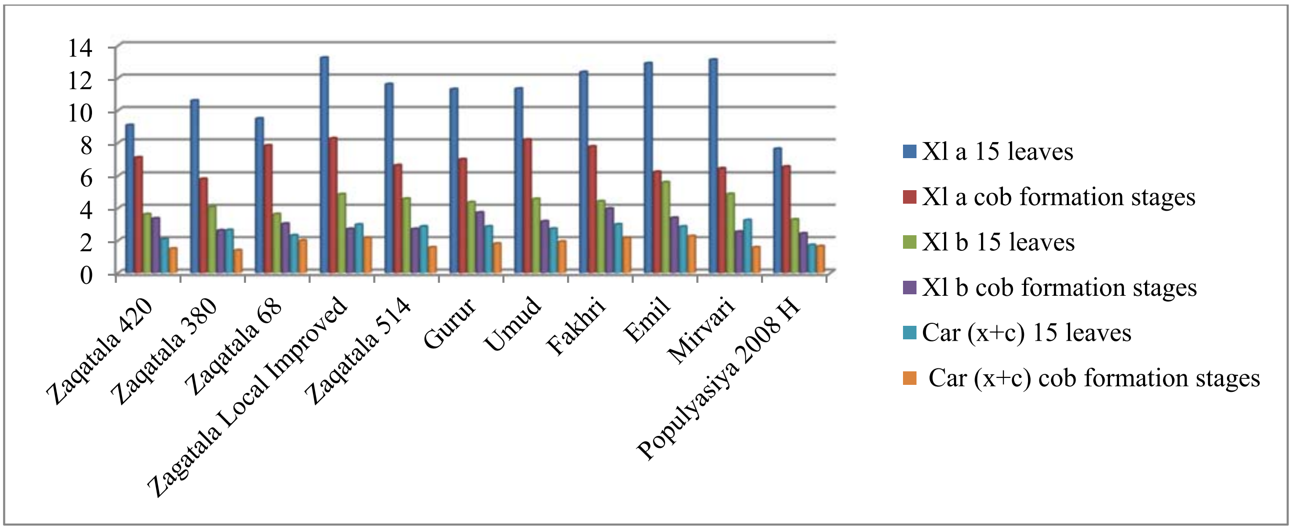


Fig. 2. Amount of chlorophyll a, b and carotenoid in maize leaves.

Thus, compared to other varieties in the varieties Zagatala Yerli Yakhshylashdyrylmysh, Gurur, and Umud the assimilating surface area and leaf index are high. Also the amount of dry biomass in the varieties Gurur, Zagatala 68 and Emil is high.

Also, the amount of photosynthetic pigments (chlorophyll a and b, carotenoids) in the studied varieties and perspective samples were determined in stages of 15 leaves and cob formation. The amount of chlorophyll creates an idea of the potential of plants such as CO_2 assimilations and yield formation, which enables them to evaluate the role of various plant organs in the formation of the yield (Andrianova, 1988, Andrianova, Tarchevskiy, 2000).

The higher amount of chlorophyll in the stage of 15 leaves was in the varieties Zagatala Yerli Yakhshylashdyrylmysh, Mirvari, Emil and Fakhri. Depending on the growing conditions, the amount of chlorophyll in the leaves varies and in sunny plants was constituted 0.68-1.30% and 1.12-1.18% of the dry weight of the leaves in shady plants. The amount of chlorophyll b was higher in Zagatala Yerli Yakhshylashdyrylmysh and Umud, while carotenoids were higher in Emil and Mirvari varieties. The amount of carotenoids is constituted 0.1-0.3% of dry weight on the leaves of higher plants, i.e. 3-6 times less than the amount of chlorophyll a and b. In the Cob formation stage, all three parameters decreased and a higher amount of chlorophyll was in Fakhri and Gurur, chlorophyll b in Fakhri and Emil and carotenoids were in the Emil, Fakhri and Zagatala Yerli Yakhshylashdyrylmysh varieties (Fig. 2).

During the harvesting period, maize varieties are characterized by productivity and structural elements of the cob. According to the duration of the growing season, with the exception of the variety Zagatala Yerli Yakhshylashdyrylmysh (120 days), the varieties under study were early- and mid-season varieties (96-110 days).

Table 2. Biometrical parameters, productivity and yield structural elements of maize varieties.

Name of variety	**Vegetation period, day**	**Plant height, cm**	**Height of insertion of upper cob, cm**	**Number of leaves at complete maturity stage, pc**	**Length of the cob, cm**	**Number of rows per cob, pc**	**Number of grains per row, pc**	**Grain output per cob, %**	**1000 kernel weight, g**	**Productivity, c/ha**
Zagatala 68	110	281	113	15.0	23.3	18.0	52.0	82.7	350	53.8
Zagatala 380	108	290	84.0	16.0	23.8	18.0	53.0	80.5	331	52.9
Zagatala 420	106	239	82.0	14.0	24.0	18.0	48.0	80.8	322	53.2
Zagatala 514	110	311	98.0	16.0	22.6	16.0	46.0	82.0	351	51.0
Zagatala Yerli Yakhs.	120	294	150	16.0	24.0	17.0	51.0	78.0	358	51.3
Mirvari	96,0	240	75.0	12.0	25.0	18.0	52.0	83.0	330	49.8
Gurur	105	247	93.0	14.0	23.3	16.0	49.0	81.2	348	50.6
Umud	105	232	92.0	13.0	22.0	16.0	48.0	83.1	339	53.7
Fakhri	105	229	83.0	13.0	22.7	17.0	46.0	83.8	343	56.9
Emil	104	260	96.0	13.0	28.0	16.0	50.0	84.0	368	58.5
Populyasiya 2008 H	106	239	82.0	14.0	24.0	18.0	45.0	80.8	352	53.2

Table 3. The correlation between biometrical parameters, productivity and yield structural elements of maize varieties.

Indicators	**VP**	**PH**	**HUC**	**NL**	**LC**	**NGPC**	**NGPR**	**GOPC**	**1000KW**	**P**
VP	1	-	-	-	-	-	-	-	-	-
PH	0.660^{*}	1	-	-	-	-	-	-	-	-
HUC	0.861^{**}	0.544	1	-	-	-	-	-	-	-
NL	0.822^{**}	0.866^{**}	0.543	1	-	-	-	-	-	-
LC	-0.236	-0.014	-0.010	0.284	1	-	-	-	-	-
NGPC	-0.089	-0.078	-0.155	0.062	0.021	1	-	-	-	-
NGPR	0.046	0.335	0.268	0.152	0.327	0.306	1	-	-	-
GOPC	-0.693^{*}	-0.415	-0.603^{*}	0.678^{*}	0.162	-0.258	-0.149	1	-	-
1000KW	0.413	0.531	0.420	0.326	0.190	-0.600	-0.275	0.049	1	-
P	-0.076	-0.264	-0.152	-0.294	0.392	-0.164	-0.182	0.535	0.168	1

Note: Abbreviations are as follows: VP - Vegetation period, PH - Plant height, HUC - Height of uppermost cob, NL - Number of leaves, LC - Length of the cob, NRPC - Number of rows per cob, NGPR - Number of grains per row, GOPC - Grain output per cob, 1000KW – 1000 kernel weight, P– Productivity

The studied parameters such as the height of plants, the height of insertion of upper cob (height of the node bearing the uppermost cob), number of leaves in the complete maturity stage varied within, 229-311cm, 75.0-150 cm and 12.0-16.0 cm respectively.

Biometrical parameters, productivity parameters and results of structural analyzes of maize varieties are given in Table 2. In the samples after drying, the length of the cob was 22.0-28.0 cm, the number of rows per cob 16.0-18.0, the number of grains per row was 45.0-53.0, the grain output per cob at threshing was 78.0-84.0%. 1000 kernel weight varied in the range of 322-375 g and productivity was 49.8-58.5 cwt/ha.

The correlation between productivity and structural elements was studied (Table 3). Positive correlations between the height of plant and vegetation period, the height of insertion of upper cob (height of the node bearing the uppermost cob) and vegetation period, the number of leaves in maturity stage and vegetation period and height of plant, and the number of leaves in maturity stage and grain output were determined.

Thus, productivity of new maize varieties Gurur, Umud, Fakhri and Emil (*Indentata Flavorubra*) varied between 56.6-58.5 cwt/ha and was 5.00-8.04% higher than the standard variety Zagatala 68.

As a result of the carried out research the maize varieties Gurur and Umud were released, varieties Fakhri and Emil were submitted to the State Service for Plant Varieties Registration and Seed Control under the Ministry of Agriculture of the Republic of Azerbaijan.

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Azərbaycan Seleksiyasının Qarğıdalı *(Zea mays* L.*)* Sortlarının Fizioloji Parametrləri

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Əkinçilik Elmi Tədqiqat İnstitutu Qarğıdalı Proqramı üzrə Zaqatala Bölgə Təcrübə Stansiyasında əldə edilmiş nəticələr əsasında C4 *Zea mays* L. bitkisinin fizioloji parametrlərinin müqayisəsi üçün yaprağın assimilyasiya səthi sahəsi, yarpaq indeksi, quru maddənin toplanması, yarpaqlarda xlorofilin miqdarı, məhsulun struktur elementləri və məhsuldarlıq təhlil edilmiş və bu göstəricilərlə böyümə prosesləri arasında əlaqə öyrənilmişdir.

Açar sözlər: *Sort, qarğıdalı, fotosintez, xlorofilin miqdarı, yaprağın assimilyasiya səthi sahəsi, yarpaq indeksi, məhsulun struktur elementləri, məhsuldarlıq*

Физиологические Параметры Сортов Кукурузы *(Zea mays* L.*)* Азербайджанской Селекции

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В статье приведены результаты, проводимых по программе Селекции Кукурузы в Закатальской зонально-опытной станции НИИ земледелия исследований, по сравнению физиологических показателей C_4 растений (*Zea mays* L.). С этой целью проанализированы такие показатели, как: площадь ассимиляционной поверхности листьев, листовой индекс, накопление сухой биомассы, содержание хлорофилла в листьях, продуктивность, структурные элементы продуктивности и изучена взаимосвязь этих показателей с ростовыми процессами.

Ключевые слова: *Сорт, кукуруза, фотосинтез, содержание хлорофилла, ассимиляционная площадь поверхности листьев, листовой индекс, структурные элементы продуктивности, продуктивность*